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SAMUX II

SYSTEM DESCRIPTION

RISD.

1.0 INTRODUCTION

SAMUX II is a Serial Addressable Multiplexer which operates at remote job sites under control of a centrally located host computer via a four wire serial communications link. Each SAMUX II is individually addressable with up to 64 SAMUX II systems connected to the host computer via an asynchronous, full-duplex serial linkage. Thus, one host computer serial port can be multiplexed to 64 remote job sites for both monitoring and control in a distributed I/O system configuration.

1.1 GENERAL DESCRIPTION

SAMUX II is a microprocessor based system which has provisions for up to 96 industrial power I/O modules, 48 channels of 12-bit analog to digital converter and 8 channels of 8-bit digital to analog converter at each remote job site. In an optional all power I/O module configuration (no analog), each SAMUX II can be expanded to 192 power I/O modules in groups of 24.

SAMUX II is mechanized on a System Backplane (SB-1) which accommodates the System Processor Board (SPB-1), the Driver Board (DB-1), the Analog to Digital Converter Board (ADC-1), and the Digital to Analog Converter Board (DAC-1). There are five board positions on the system backplane. The system processor board has a fixed position while the other boards can be installed in any of the remaining four board positions. The installation of a board in a particular position is usually determined by the mechanical needs of the system with respect to cable layout, wiring needs and functional grouping of digital and/or analog I/O.

The System Processor Board (SPB-1) contains the 6802 microprocessor with 1K byte of RAM, up to 4K bytes of program memory, system timer, communication circuits and the watchdog timer. SAMUX II firmware provides the user with system commands and a message protocol which allows direct manipulation and control by a high level language like FORTRAN or BASIC. Due to the programmable nature of SAMUX II, a user can customize the firmware to comply with a particular control and/or monitoring function, as well as comply with an existing host computer message protocol.

The System Processor Board (SPB-1) allows five different communication configurations to match the environment needed by the host computer as well as the job site (s). The desired communication option is selected by programming plug from the following list:

A. CO1 for RS232 to RS422
B. CO2 for 20 ma to RS422
C. CO3 for 20 ma to Optical Coupler
D. CO4 for RS422 to RS422
E. CO5 for Optical Coupler to Optical Coupler

The Driver Board (DB-1) contains the circuitry to accommodate complete operation of two PB-24 mounting racks with up to 48 power I/O modules. Each PB-24 mounting rack has provisions for 24 power I/O modules which are position independent. These modules are plug-in and each position is individually fused with an LED status indicator for each module. An industrial type barrier strip provides convenient connection between each I/O module and its job function. A 50-pin edge connector provides the connection between the PB-24 and the SAMUX II system backplane via a 50 conductor ribbon cable.

The analog to Digital Converter Board (ADC-1) provides up to 48 channels of 12-bit ADC in increments of 8 channels. The basic ADC-1 is furnished with 8 channels. Expansion is by plug-in IC (8 channels per IC) and can be done at the factory or in the field. The analog input can be either unipolar or bipolar. The voltage range is selectable from 0 to +5 volts, 0 to +10 volts, $\pm$ 2.5 volts, $\pm$ 5 volts, and $\pm$ 10 volts.

The Digital to Analog Converter Board (DAC-1) provides up to 8 channels of 8-bit DAC in increments of 2 channels. The basic DAC-1 is furnished with 2 channels. Expansion is by plug-in IC (2 channels per IC) and can be done at the factory or in the field. The analog output is bipolar with a voltage range of $\pm$ 10 volts.

2.0 SYSTEM FEATURES

SAMUX II is a microprocessor based system for both monitoring and control functions at remote job sites which communicates with the centrally located host computer via two twisted pair wires. A summary of the main system features is as follows:

* EXPANDABLE POWER I/O
* DIGITAL AND ANALOG I/O
* EXTENSIVE COMMUNICATIONS ATTACHMENTS
* SECURE COMMUNICATIONS
* EFFICIENT PROTOCOL
* VERSATILE COMMAND SET
* TIME DELAY FUNCTIONS
* LATCHED INPUTS
* EVENT COUNTERS
* WATCHDOG TIMER

SAMUX II has been mechanized in a modular fashion to allow easy expansion of both digital and analog I/O. The digital I/O is expandable through the use of PB-24 mounting racks which can each accommodate up to 24 I/O modules. In an all digital configuration, SAMUX II can attach up to 8 PB-24 mounting racks which provides up to 192 power I/O modules. The analog functions are mechanized on individual boards which provide channel expansion on the board itself through the use of plug-in ICs. SAMUX II with combined digital/analog I/O can accommodate up to 96 digital I/O points, up to 48 analog input points and up to 8 analog output points.

SAMUX II provides serial communications linkage to the host computer via two twisted pair wires with a choice of RS-232, 20 ma current loop, RS-422, or optically coupled interfaces to match host computer and job site requirements. Secure communications between SAMUX II and the centrally located host computer is vital for proper system operation. SAMUX II checks the communications four ways:

A. Character Parity - Each ASCII character is checked for parity

B. Message Checksum - Each message contains a checksum character for verification of message integrity

C. Message Syntax Check - Each Message is checked for proper syntax

D. Command Echo - If desired, each command can be retransmitted back to the host computer where it can be verified prior to sending an execute command.

There are eleven error types which SAMUX II can identify to the host computer; two for data errors; six for message content or syntax; and three for system integrity which is continually monitored.

SAMUX II communicates with the host computer in a protocol which has been selected for maximum security as well as ease of manipulation in a higher level language. The host computer can issue a command message and an execute message. SAMUX II can respond with an echo message as well as an acknowledge execute message. A typical sequence has the host computer transmitting a command message to a specific SAMUX II. The selected SAMUX II retransmits the command back to the host with the first message character indicating proper receipt of transmission (ACK). If the message was correctly received by the SAMUX II, the host computer will transmit a single character message (E) to execute the command. If the command does not require any data to be transmitted, SAMUX II will respond with a two character message acknowledging the execute command and will execute the command. The message will consist of an acknowledge character (ACK) and a carriage return (C/R). If the command requires data to be transferred, SAMUX II will respond with a DATA message which includes ACK, data characters, checksum, and C/R. In the event of an error in the command message transfer, the acknowledge character will be replaced with the no acknowledge character (NAK) and the command will not be executed. The host computer can then interrogate SAMUX II to determine the exact nature of the error. The SAMUX II error types are as follows:

1. Configuration Error (Write to Input Module)
2. Reset Flag
3. Data Field Error (Number Too Large)
4. Undefined Command

5. Parity Error
6. Message has more than 80 Characters
7. Checksum Error
8. ROM Error
9. RAM Error
10. Bank Error (Address Beyond Number of PB-24s on-site)
11. Modifier Field Error (Number Not in Range)

There are eight output module positions per PB-24 (first 4 PB-24s only) which can be selected for output in a timed mode of operation. The timed mode can be either a delay function before specified action (go to active or inactive state) or a pulse generator function which pulses the output module to the specified state (active or inactive) for a selected interval of time. The time interval is programmable from 10 milliseconds to 10.92 minutes with a resolution of 10 milliseconds

SAMUX II provides **latched inputs** for recording momentary events. System commands configure the input modules for latched operation on either a positive or negative transition as well as read and clear and latch condition on command. All input modules can function in the latched or non-latched mode. The choice is made by command from the host computer.

Three input module positions per PB-24 (first 4 PB-24s only) can function as **event counters** to record a count of external events. The count ranges from 0 to 65535 with **commands to clear, start, stop, read, and read and clear** the individual counters issued by the host computer.

The selection of station address (1 of 64 possible), baud rate (110 to 9600 baud), and other communication options (parity, stop bits, etc.) are made on **Driver Board #1** via two eight position switches. Since each SAMUX II can accommodate up to four Driver Boards (DB-1s), a programming plug is used to set the address of each DB-1. There are five programming plug positions on the component side of each DB-1. The top four select individual addresses; the top position selects Driver Board #1 and the bottom position selects Driver Board #4. The fifth position, if used, activates I/O module position 15 of the first PB-24 for use with the watchdog timer. The I/O module should be a

normally open output module. When the watchdog timer indicates a fault condition the I/O module, which was activated to the closed state, will open and indicate the condition. This output module should feed a latching circuit as the condition which caused the alarm can go away.

3.0 MESSAGE PROTOCOL

SAMUX II offers two command and response formats to satisfy both network security and transaction response time. The **command echo mode** echoes the entire command while the **non-echo mode** simply acknowledges receipt of the command with a two character response. The choice of which response SAMUX II makes to a command from the host computer is determined by the end of message character. A carriage return **(C/R)** selects echo mode while **ETX** selects the non-echo mode.

An example of the protocol in a complete message transaction is as follows:

A. Message from Host Computer to SAMUX II
   STX STA.# CMD D1 D2 D3----D1 D2 D3 CKSM C/R or ETX

B. Message from SAMUX II to Host Computer
   1. Echo Mode (C/R)
      ACK STA.# CMD D1 D2 D3----D1 D2 D3 CKSM C/R
   2. Non-Echo Mode (ETX)
      ACK C/R

C. Message from Host Computer to SAMUX II
   E

D. Message from SAMUX II to Host Computer
   1. Acknowledge Execute (No Data Transfer)
      ACK C/R
   2. Acknowledge Execute (Data Transferred)
      ACK D1 D2 D3----D1 D2 D3 CKSM C/R
   3. Not Acknowledge (Identifiable Error)
      NAK D1 D2 C/R
   4. No Response (Parity Error, Checksum Error or Syntax Error)

A complete message transaction thus requires four separate and distinct messages between the host computer and the specified SAMUX II. The host computer initiates the transaction with a command to 1 of the possible 64 SAMUX II units in a network. The addressed SAMUX II either echoes the entire message back to the host computer or simply acknowledges receipt of the command. The host computer at this point transmits the execute command which is a single character (E) to SAMUX II. The response from SAMUX II to the execute command is either an acknowledgment (no data transferred to the host computer) that the command has been executed or an acknowledgment with the requested data. In the event of an error, SAMUX II either responds with a No Acknowledge message which identifies the error type or does not respond at all which indicates a parity error, a checksum error, or a syntax error. The exact nature of the error can be determined by the Host Computer with a Read Station Error Type command.

The STX character denotes the beginning of a message from the host computer. The following character STA.# determines which SAMUX II unit is being selected. The CMD character defines which command is to be executed by SAMUX II. The data field D1 D2 D3 is a variable length field which is dependent upon the type command as to whether there are any data characters, or, if so, how many data characters are contained in this field. The checksum character, CKSM, is generated and checked on message content. The C/R character specifies echo mode and the ETX character specifies non-echo mode. The ACK character indicates acknowledgment while NAK indicates non-acknowledgment due to an error condition. The basic station address at each SAMUX II site is selected via an eight position switch on Driver Board #1. Seven bits are used to allow selection of up to 128 PB-24s. The PB-24s (in groups of two) can be physically located at a number of SAMUX II sites -- two PB-24s at each site would allow up to 64 SAMUX IIs in one network; eight PB-24s at each site would allow up to 16 SAMUX IIs in one network. Each station address is therefore dependent upon the number of PB-24s (in groups of two) preceeding this station in the network. The station address is used to direct the flow of data to and from each PB-24 mounting rack attached to the System Backplane (SB-1).

The first station address works with the PB-24 mounting attached to port 0; the second station address works with the PB-24 mounting rack attached to port 1, etc. Up to eight PB-24s can be attached to one System Backplane. A command issued to the first PB-24 mounting rack at a station can address 8, 16, or 24 I/O modules. In addition, this command can address I/O modules on the second, third, etc. PB-24 mounting racks simply by extending the data field portion of the command.

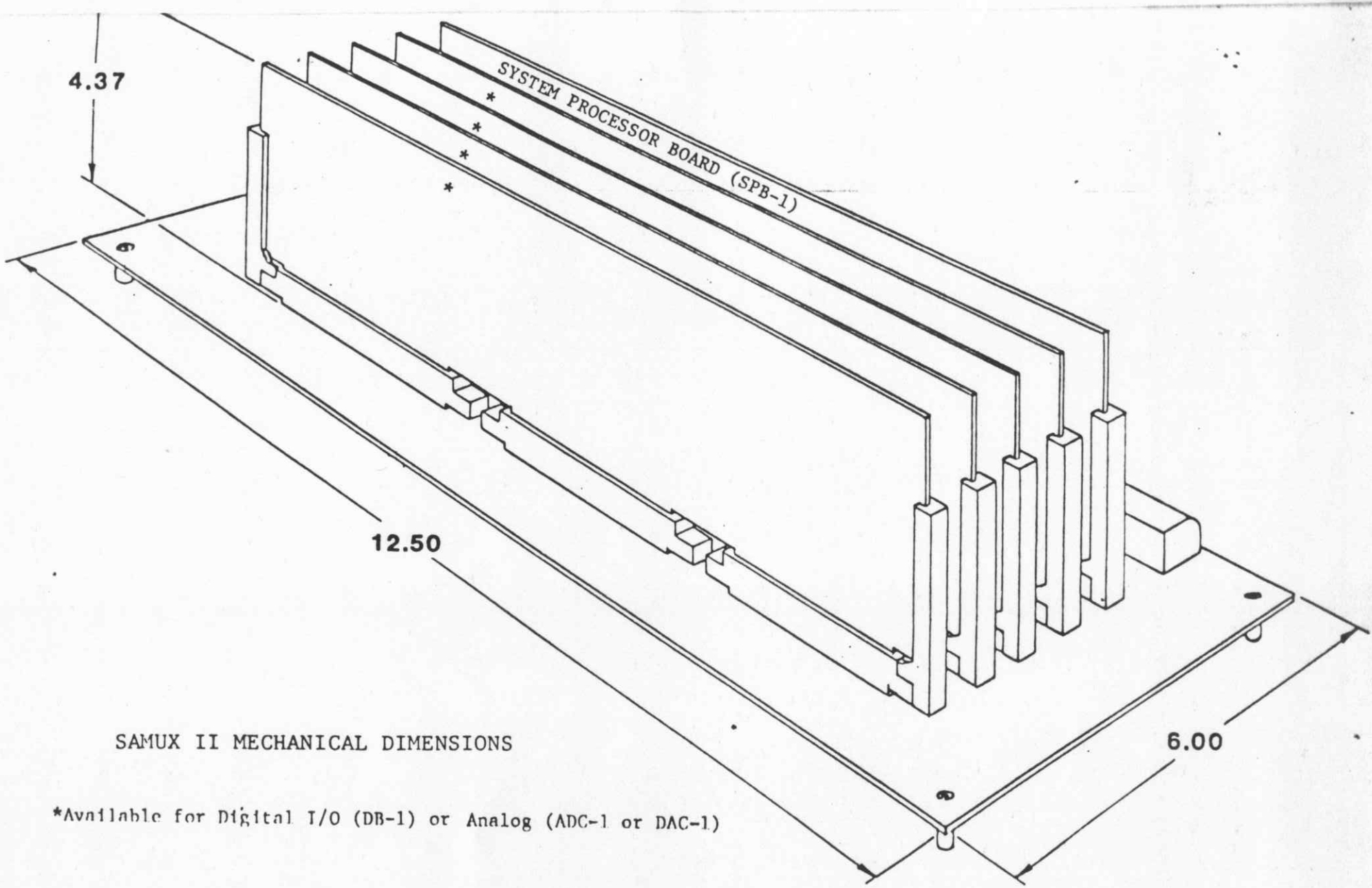
The content and extent of the data field portion of a SAMUX II command varies from none to 72 data bytes. Five commands do not need a data field. These commands are Clear Station Errors and Counters, Clear Latch Modules, Read Station Error Type, Read Station Error Counter, and Reset. Eight commands have a modifier field of up to four bytes which further defines command execution. These commands are Read Input Modules, Read and Clear Latch Modules, Start Counter, Stop Counter, Read Counter, Read and Clear Counter, Clear Counter, and Input ADC Data. Two commands have a modifier field as well as a data field for a complete description of command execution. These commands are Time Delay Function and Output DAC Data. Finally, there are four commands which contain a variable length data field of from three to 72 bytes. These commands are Configure System, Write Output Modules, Configure Latch Input Modules, and Set Latch Zero/Ones Pattern.

The standard SAMUX II command set has 19 commands which define the operational capability of SAMUX II at the job site. The host computer and SAMUX II work together in an active/passive mode with the host computer being the controlling element. Once commanded by the host computer to perform the specified task, SAMUX II proceeds independently in the execution of the assigned task.

The SAMUX II command set is as follows:

COMMAND	HEX CODE	ASCII	CAMPO DATI
A. Clear Station Errors and Counters	33	3	N/D
B. Configure System	35	5	3÷72 bytes
C. Write Output Modules	31	1	3÷72 "
D. Read Input Modules	32	2	1÷4 "

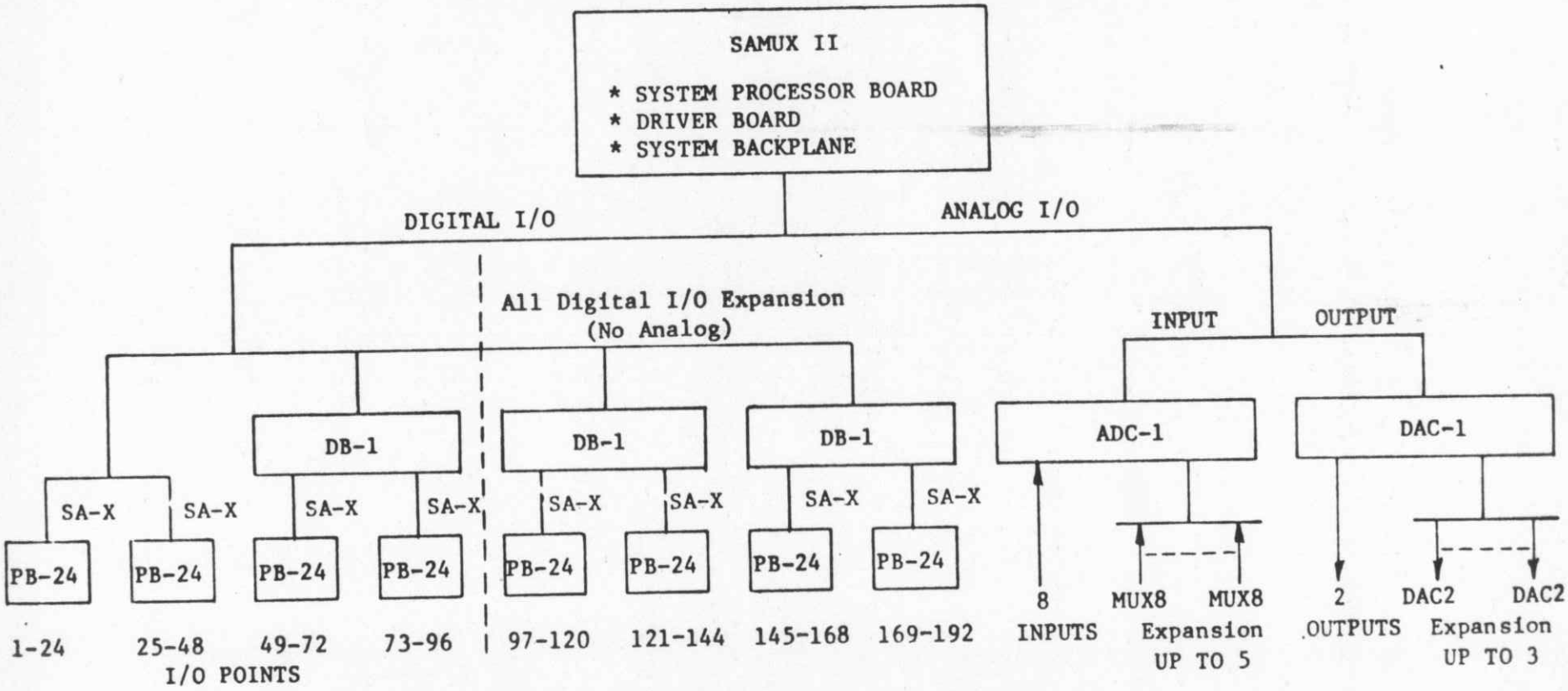
COMMAND	HEX CODE	ASCII
E. Configure Latch Input Modules	3F	?
F. Set Latch Zero/Ones Pattern	42	B
G. Read and Clear Latch Modules	40	@
H. Clear Latch Modules	41	A
I. Start Counter	3D	=
J. Stop Counter	3A	:
K. Read Counter	36	6
L. Read and Clear Counter	4B	K
M. Clear Counter	38	8
N. Time Delay Function	43	C
O. Input ADC Data	4A	J
P. Output DAC Data	4B	K
Q. Read Station Error Type	3C	<
R. Read Station Error Counter	34	4
S. Reset System	4D	M



SAMUX II MECHANICAL DIMENSIONS

*Available for Digital I/O (DB-1) or Analog (ADC-1 or DAC-1)

SAMUX II CONFIGURATOR



NOTES:

1. Basic SAMUX II provides DB-1 for first 48 I/O Points.
2. Cable SA-X per PB-24 where X = 2, 4, 6, or 10 feet.
3. PB-24 can accommodate up to 24 I/O modules in any mix, i.e., Input, Output, AC or DC.
4. Basic ADC-1 includes 8 channels of analog input.
5. ADC-1 expansion to 48 channels (24 Channels Differential) via up to 5 MUX8 units.
6. Basic DAC-1 includes 2 channels of analog output.
7. DAC-1 expansion to 8 channels via up to 3 DAC2 units.
8. The Time Delay function can be mechanized on module positions 0 through 7 of the first 4 PB-24s.
9. The Event Counter Function can be mechanized on module positions 0, 8 and 16 of the first 4 PB-24s.